RISK FACTORS FOR DEATH AND PROGNOSIS VALUE OF REVISED BAUX SCORE FOR BURN PATIENTS WITH INHALATION INJURY

FACTEURS DE RISQUE DE DÉCÈS ET VALEUR PRONOSTIQUE DU SCORE DE BAUX MODIFIÉ CHEZ LES BRÛLÉS AYANT INHALÉ DES FUMÉES

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SUMMARY. A retrospective study was conducted on 314 burn patients with inhalation injury admitted to the National Burn Hospital during the period 2015-2019. The results showed that adult and male was predominant (81.9% and 77.7%), with burns mostly caused by flame (93.6%) and burn extent of 68.6±24.3% and deep burn area of 44.6±25.2% total body surface area. Rate of required mechanical ventilation patients was 95.22%. Common complications were multiple organ failure (41.9%), pneumonia (29.9%), ARDS (25.5%) and septic shock (23.8%), with a mortality rate of 85.4%. Multivariate logistic analysis indicated that burn extent and age were independent risk factors for death of patients with inhalation injury. SMR of rBaux score was 1.01 with AUC of 0.84, Youden index 113, sensitivity 82.09%, specificity 70.21%. The SMR of adult and elderly patients was relatively close to 1 (1 and .97 respectively). In addition, the AUC value for the elderly was highest (.95) followed by adult patients (.84). However, predicting the value of rBaux on children with inhalation injury was quite low (SMR=1.57; AUC = 0.4). There is a need to determine an optimal prognosis score for children with inhalation injury.

Keywords: inhalation injury, mortality, revised Baux score

RÉSUMÉ. Nous avons réalisé une étude rétrospective sur 314 patients ayant inhalé des fumées hospitalisés dans le CTB national entre 2015 et 2019. Les hommes (77,71%), les adultes (81,85%) et les brûlés par flamme (93,6%) étaient majoritaires dans ce groupe. La surface brûlée moyenne était de 68,6 +/- 24,3% dont 44,6 +/-25,2% de profond. Une ventilation mécanique a été nécessaire dans 95,22% des cas. Les complications les plus fréquentes étaient les défaillances multiviscérales (41,9%), les pneumonies (29,9%), le SDRA (25,5%) et les chocs septiques (23,8%). La mortalité était de 85,4%. En analyse multivariée, l'âge et la surface brûlée ressortaient comme des facteurs de risque indépendants de mortalité. Le Baux modifié avait un SMR de 1,01; une AUC_{ROC} de 0,84; un index de Youden à 113, une sensibilité de 82,09% et une spécificité de 70,21%. Les SMR étaient proches de 1 chez les adultes (1) et les sujets âgés (0,97). La valeur la plus élevée de l'AUC (0,95) correspondait à la cohorte «sujets âgés», suivie de la cohorte «adultes» (0,84). Le Baux modifié est peu efficace chez l'enfant (SMR 1,57 ; AUC 0,4). Il est nécessaire de développer un score pronostique pour les enfants brûlés ayant inhalé des fumées.

Mots-clés: brûlure, inhalation de fumées, mortalité, Baux modifié

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Introduction

Management of inhalation injury is complicated and despite significant advances in early resuscitation, skin substitute, surgical intervention and enteral nutrition, the mortality rate of patients with inhalation injury has not progressed significantly for decades.[1,2] Annually, over one million burns occur in the United States and about 20% suffer inhalation injury resulting in prolonged mechanical ventilation and increased mortality from 25% to 65% due to related complications such as pneumonia and acute respiratory distress syndrome (ARDS).[3,4]

The use of a prognosis score may help the health facility to evaluate and optimally use resources in burn care and therapy. Since it was first introduced in 1961, the Baux score has been used in most burn facilities to predict the death rate of burn patients.[5] However, with the development of advanced technology, significant improvements have been achieved to reduce the mortality rate of burn patients.[6] Currently, the Baux score has been considered not appropriate. Based on that, the revised Baux score (rBaux), which was proposed by Osler in 2010 by adding inhalation injury as a score component besides age and burn extent, has been mostly applied in developed countries.[7]

To date, there have been few reports about characteristics and value of the rBaux score in burn patients with inhalation injury in developing countries.[8,9] The objective of this study was to determine characteristics, factors influencing mortality and predictability of rBaux score in patients with inhalation injury at the National Burn Hospital, Hanoi, Viet Nam.

Patients and methods

A retrospective study was conducted on 314 burn patients with inhalation injury admitted to the burn intensive care unit, National Burn Hospital, Hanoi, Viet Nam during the period 2015-2019. Inhalation injury was diagnosed based on the circumstance of injury (burn occurred in closed space), clinical manifestations (facial burn, soot in mouth or pharynx, hoarseness and carbonaceous sputum) and confirmation by bronchoscopy during the first 3 days after burn. Treatment of inhalation injury included chest physiotherapy, aerosolized heparin and salbutamol every 4 hours and mechanical ventilation as indicated. The collection criteria included age, gender, causal agent, burn extent, full thickness burn area, comorbidity and cotrauma, length of mechanical ventilation, complications and death or survival. Relationships between mortality and related factors were analyzed by univariate and then regression analysis to determine the independent factors affecting mortality.

The rBaux score was calculated as follows:[7]

Age (years) + burned extent (%) + (17 x I)

in which: $I = 1$ for patient with inhalation injury; $I = 0$ for patient without inhalation injury.

To assess the predictability of the rBaux score, we used the standard mortality ratio (SMR), the area below the curve (AUC) and the Youden index along with the sensitivity, specificity, accuracy level. The SMR was calculated as follows:[10]

SMR = (actual death number/predicted death number).

The number of predicted deaths was calculated by the number of patients with rBaux score of 100 or more. The meaning of SMR is explained as follows: the closer the SMR is to 1, the more accurate the prediction is:

- SMR = 1 means the forecast is 100% accurate.
- SMR <1 means predictability is higher than reality
- SMR >1 means the predictability is lower than reality.

Data were collected, presented as mean or median (if unstandardized distribution) and analyzed using Stata software version 14.0, with p value <.05 regarded as the significant level. This study was approved by the hospital's Committee for Human Research Ethics.

Results

During the period from 2015-2019, there were 3029 severe patients with burn extent from or over 20% total body surface area (TBSA) admitted to the National Burn Hospital. Of them 314 patients were diagnosed with inhalation injury, accounting for 10.4% (data not shown). Adults and males were predominant (81.9% and 77.7% respectively), with

burns mostly caused by flame (93.6%). There were 26 (8.3%) patients with comorbidity. Average burn surface area was 68.6±24.3% TBSA and mean of deep burn area was 44.6±25.2% TBSA. It is noted that most patients underwent mechanical ventilation (95.2%). The median of mechanical ventilation time was 95.5 hours. The highest incidence of complication was multiple organ failure (42%), followed by pneumonia (29.9%), ARDS (25.5%) and septic shock (23.9%). Overall mortality rate was 85.4% (*Table I*).

Table I - Patient characteristics and burn features (n=314)

Parameter	Subgroup	N	%
Age	Children (<16 Y.O)	18	5.7
	Adult (16-59 Y.O)	257	81.9
	Elderly (≥60 Y.O)	39	12.4
Gender	Male	244	77.7
	Female	70	22.3
Causal agents	Scalds	10	3.2
	Flame	294	93.6
	Other	10	3.2
Comorbidity		26	8.3
Cotrauma		4	1.3
Burn extent, % TBSA		68.6 ± 24.3	
Full thickness burn area, % TBSA		44.6 ± 25.2	
Mechanical ventilation		299	95.2
Ventilated time, h, median		95.5 (24-242)	
Pneumonia		94	29.9
ARDS		80	25.5
Septic shock		75	23.9
MOF		132	42
Death		268	85.4

Y.O. = year old; TBSA = total body surface area; ARDS = acute respiratory distress syndrome; MOF = multiple organ failure

Univariate analysis of association between treatment outcomes and related factors is shown in *Table II*.

Table II - Relationship between mortality and parameters

Factors	Subgroup	Survivor	Death	p
Gender, n,%	Female	10 (14.3)	60 (85.7)	.92
	Male	36 (14.8)	208 (85.2)	
Age, n,%	Children	7 (38.9)	11 (61.1)	.004
	Adult	37 (14.4)	220 (85.6)	
	Elderly	2 (5.1)	37 (94.9)	
	Average, year	32.2 ± 15.3	41.5 ± 16.9	.0006
Comorbidity,n,%	No	40 (13.9)	248 (86.1)	.20
	Yes	6 (3.8)	20 (96.2)	
Burn extent	<40 %	20 (45.4)	24 (54.6)	.0001
	≥40 %	26 (9.6)	244 (90.4)	
	Average, %TBSA	45.1 ± 26.9	72.7 ± 21.5	.0001
Deep burn area	<20 %	26 (49.1)	27 (54.9)	.0001
	≥20 %	20 (7.7)	241 (92.3)	
	Average, %TBSA	23.3 ± 3.4	48.3 ± 23.5	.0001
Mechanical ventilation, n,%	No	8 (53.3)	7 (46.7)	.0001
	Yes	38 (12.7)	261 (87.3)	
Ventilated time, h, median		122 (16-260)	96 (24 - 242)	.96

TBSA = total body surface area

Compared to the survivor group, the non-survivors were significantly older and had larger burn extent and deep burn area (p < .005). The non-survivor group had a significantly higher rate of mechanical ventilation (87.3%

vs. 12.7%; p < .01). It is also noted that gender, associated disease and duration of mechanical ventilation did not significantly affect mortality rate (p >.05).

Multivariate regression analysis indicated that only increased age and burn extent were independent factors for death (*Table III*). An increased 1% of burn extent resulted in a .03 probability unit of death (OR = 1.03) and that was .04 in the case of age (OR=1.04).

Table III - Multivariate analysis of death and relating factors

Factors	Coef.	OR	P	95% CI
Age	.04	1.04	.00	1.01 ÷ 1.06
Burn extent	.03	1.03	.04	1.01 ÷ 1.05
Deep burn area	.02	1.02	.06	0.99 ÷ 1.04
Mechanical ventilation	1.29	3.66	.06	0.91 ÷ 14.73
Cons.	-3.76	.02	.00	0.00 ÷ 0.13

Coef. = coeficience; OR = odds ratio; CI = confidence interval; Cons = Constance

Data from *Table IV* and *Fig. 1* indicate that of 314 patients studied, 268 patients died with the standard mortality rate calculated according to the rBaux score of 1.01, AUC: 0.84, Youden index: 113 with sensitivity of 82.09%, specificity of 70.21% and an accuracy of 80.32%. Analysis by age groups showed that the SMR of adult and elderly patients was relatively close to 1 (1 and .97 respectively). In addition, the AUC value for the elderly was highest (.95) followed by adult patients (.84). For children, SMR was far from ideal (1.57) and AUC value was only 0.59.

Table IV - SMR and AUC for rBaux score according to age groups

Age group	Actual death	Predicted death	Youden index	Sensitivity	Specificity	AUC	SMR
Children	11	7	87	71.42	63.63	.40	1.57
Adult	220	220	113	75.67	83.18	.84	1.0
Elderly	37	38	129	100	70.27	.95	.97
All patients	268	265	113	82.09	70.21	.84	1.01

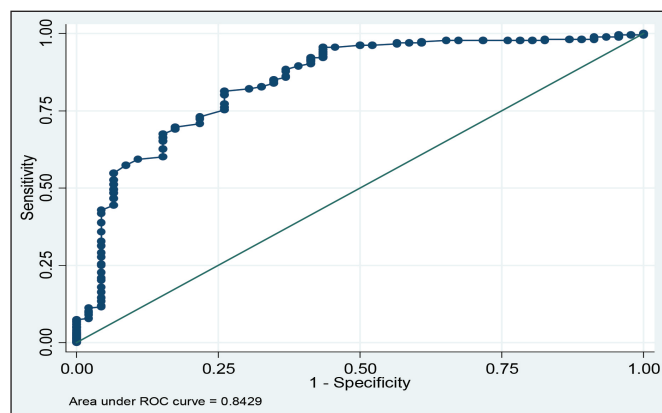*SMR = standard mortality ratio; AUC = area under the curve*

Fig. 1 - Overall AUC value of revised Baux score for mortality

Discussion

Inhalation injury is classified as severe burn with three main types of injury, including heat injury to upper airway, lower airway and alveoli injury due to combustion products, chemical irrigation and systemic toxicity of carbon monoxide and cyanide.[11,12] Worldwide, the incidence of inhalation injury is reported in 5-30% of total burn patients.[13] Inhalation injury was noted in about one-third of all burn cases and responsible for about 90% of deaths among burn patients.[14,15] In 2017, the American Burn Association reported that the incidence of inhalation injury was about 10.3% of burn patients.[3] In our study, about one in ten severely burned patients (10.4%) suffered inhalation injury.

Despite advances in early diagnosis and active management, the mortality rate for inhalation injury is still high and has been confirmed as one of the predictors of death amongst burn patients.[16] According to previous reports, the mortality rate of burn patients with inhalation injury was 20% higher than that of patients who did not suffer inhalation injury.[17] In addition, if secondary pneumonia develops, the mortality rate is 60% higher.[18] A study by Kadri et al. indicated that among patients with inhalation injury, age >60 years old and burn extent >20% TBSA were risk factors for death in patients who developed acute lung injury after inhalation injury.[19] It is also noted that inhalation injury is often present in patients with larger burn extent. In our study, patients with inhalation injury had a burn surface area over 60% TBSA or deep burn area over 40% TBSA. It explained why the mortality rate was high (85.35%). Current study also indicated that increase in burn extent and age are independent factors affecting mortality in patients with inhalation injury.

An optimal prognosis score should meet required conditions, including high degree of accuracy, simplicity, and ease of application. Following the Baux score, a number of predictive scales have been introduced. The abbreviated burn severity index (ABSI) score was introduced in 1982 by Tobiasen and colleagues.[20] This model used age, gender, burn extent, inhalation injury and the presence of deep burn to predict mortality rate. In 1998, Ryal introduced a score using three factors, namely age, burn surface area and inhalation injury.[17] The model of McGwin and colleagues in 2008 used age, burn extent and inhalation injury, co-trauma and pneumonia.[21] Other prognosis scores include the FLAMES score (2009) and the BOBI score (2009).[22,23] However, due to being complicated, the clinical use of these scores is still limited. Meanwhile, the Baux score is simple, easy to apply in clinical practice and has been used in predicting outcome for burn patients around the world.

The AUC is one of the criteria to evaluate the prognosis level of the scale and most authors consider AUC of 0.9 and above as highly accurate.[24] Since the rBaux Score was introduced by Osler, numerous reports have been published about the prognosis value of this score using AUC value.[25,26,27] Panter et al. evaluated prognosis value of prognosis scores on 492 burns in the intensive care unit (ICU) and found that rBaux was the best prognosis score with AUC of 0.919.[28] Dokter and colleagues studied 4389 burn patients and concluded that the rBaux score was simple and accurate with a higher predictive value of death than the Baux score (AUC: 0.96 compared to 0.81).[29] Lip et al. also demonstrated that the rBaux score had the best AUC value of 0.94 to predict burns mortality.[9] Study by Halgas et al. also concluded that the rBaux score was both accurate and easy to calculate.[30] In our study, SMR of the rBaux score was closer to 1 so in general, the rBaux score has accurate predictive value.

It is noted that the application of prognosis scores in practice shows the difference in accuracy of prognosis scores between different age groups. Current study indicated that for pediatric burn patients, the prognosis value of rBaux score is less accurate and this should be considered when clinically applied. Taylor et al. indicated that the "one size fits all" models for predicting outcomes do not accurately reflect the outcomes for seniors and children with burns.[31] Children are not small adults, their functions and organs are not fully developed, so the morbidity is often severe and outcomes are not the same as for adults. Study by Spies and coworkers on pediatric burn patients found that if all variables were integrated into the predictive model, the results were predicted with 97% accuracy. However, if only using demographic characteristics including age, burn extent and inhalation injury, the results were predicted with an accuracy of only 51%.[32] It is also noted that Osler et al.,

when proposing the rBaux score, acknowledged the different predictive accuracy of this formula across different age groups.[7] Because the number of childhood inhalation injuries in our study as well as that of other studies was quite small, it is necessary to have studies with larger sample sizes to get accurate conclusions. Therefore, the application of the prognostic scale may have to pay attention to the appropriate age groups.

Conclusion

We have shown that the mortality rate of patients with inhalation injury is still very high. An increased burn extent and age are independent factors for death. The rBaux score is only accurate in patients with inhalation injury among the elderly and acceptable in adult patients. There is a need for research to build a prognosis score for children with inhalation injury.

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